DOCUMENT RESUME

ED 385 213 IR 017 204

TITLE	Successful Technology Transfer in Colorado: A Portfolio of Technology Transfer "Success Stories."
INSTITUTION	Colorado Advanced Tech. Inst., Denver.
SPONS AGENCY	Economic Development Administration (DOC), Washington, D.C.
PUB DATE	[94]
CONTRACT	G05-25-2600
NOTE	28p.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Biotechnology; Competition; Economic Development; Information Dissemination; Information Technology; Information Transfer; *Private Sector; Problem Solving; *Public Sector; Research and Development; *Scientific and Technical Information; Success; Technological Advancement; *Technology Transfer
IDENTIFIERS	*Colorado; Global Markets; Infrastructure

ABSTRACT

The examples in this portfolio demonstrate how technology transfer among universities, businesses, and federal laboratories solve real-world problems, and create new goods and services. They reveal how, through strengthening the infrastructure joining private and public sectors, Colorado can better compete in the global marketplace. All of the programs in this portfolio have received support from the Colorado Advanced Technology Institute (CATI). The technology transfer success stories include: (1) biotechnology programs, such as Colorado Bio/Medical Venture Center (CBVC), Colorado Bioprocessing Center, and Colorado Institute for Research in Biotechnology (CIRB); (2) information technology programs, including Colorado Advanced Software Institute (CASI), Colorado Open Systems Consortium (COSC), Colorado Rural Telecommunications Project, Optoelectronic Computing Systems Center (OCSC), and SuperNet--The Colorado Computer Network; (3) technology transfer, such as Boulder Technology Incubator, Colorado Institute for Technology Transfer and Implementation (CITTI), Colorado Technology Action Consortium (COTAC), and Mid-America Manufacturing Technology Center (MAMTC); and (4) advanced materials, including Colorado Advanced Materials Institute (CAMI) and Center for Separations Using Thin Films (CSTF). Information is provided on how to find out more about CATI, and the 1993-94 CATI commissioners are listed. (MAS)

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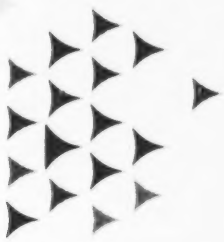

Successful Technology Transfer in Colorado

A Portfolio of Technology Transfer "Success Stories"

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Technology transfer is a multi-disciplinary activity, and it has multiple dimensions. So, often it is difficult to pin-point precisely how technology transfer works, or why it is such an important economic development activity. The examples in this portfolio demonstrate how technology transfer among universities, businesses and federal laboratories solve real-world problems, and create new goods and services. They reveal how, through strengthening the infrastructure joining private and public sectors, Colorado can better compete in the global marketplace.

All of the programs in this portfolio have received support from the Colorado Advanced Technology Institute (CATI). CATI's mission is:

> *To establish Colorado as the acknowledged world leader in selected technologies so as to be the location of preference for conduct of education, research, product development, and manufacturing in these technologies.*

As Colorado's science and technology development agency, CATI functions as a catalyst, providing a unique mechanism by which the state's research universities and advanced technology companies can come together to build the state's research infrastructure. As these "success stories" demonstrate, the results can be impressive.

- With support from CATI, academic and medical researchers have been able to engage in biomedical research which is leading to treatments for rheumatoid arthritis, rheumatic fever, cardiovascular disease, cancer, and AIDS.

- CATI support has enabled businesses to work in collaboration with academic researchers to solve problems in welding, fiber-optic sensors, space flight crew support, shape memory alloys, high temperature super conducting materials, natural gas engine emissions, and more.

- CATI-sponsored programs are enabling Coloradans to access the Information Superhighway at a cost that is not prohibitive, and in ways that foster community economic development through telecommunications.

- The collaborations profiled in this portfolio have generated multimillion dollar grants from the National Institutes of Health, the Department of Defense and NASA. In 1993, CATI programs received matching support from over 200 corporations, 17 financial institutions, 13 nonprofit organizations, and 59 government-funded organizations.

The private/public infrastructure catalyzed by CATI has resulted in important technological advancements. In addition, it has brought substantial Federal funds to Colorado, and industry support of academic research to Colorado universities. Further, the private/public infrastructure catalyzed by CATI has enabled the creation of an environment that is attractive to high-technology industries. Without CATI programs, either the technological advances profiled here would not have happened, or someone outside of Colorado better organized and more resourceful probably would have beat us to them. We are pleased to be able to show you what CATI programs have accomplished.

Jennifer Stone Gonzalez
February 25, 1994

HOW TO FIND OUT MORE ABOUT THE COLORADO ADVANCED TECHNOLOGY INSTITUTE

Doing business with one of CATI's programs typically begins with a phone call. If you would like to know more about how become involved with CATI's programs, please contact the appropriate individual listed below.*

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* All telephone numbers listed are within the 303 area code, unless otherwise noted.

CATI COMMISSIONERS 1993-94

The activities and staff of the Colorado Advanced Technology Institute are directed by a ten-member commission; seven, from the private sector, are appointed by the governor; the Colorado Commission on Higher Education appoints one member, and the House and Senate each appoint one member.

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Colorado Bio/Medical Venture Center (CBVC)

Lewis Kontnik, Executive Director

The Colorado Bio/Medical Venture Center (CBVC), based in Lakewood, is a new-business incubator for fledgling biomedical companies. Three buildings on the 22-acre AMC Cancer Research Center provide physical space for emerging biomedical companies spinning out of Colorado's universities, major biomedical companies, or from companies relocating to Colorado from outside the state. The facility includes lab, office and resource space.

Formation and Launch of Supragen from the National Jewish Center for Immunology

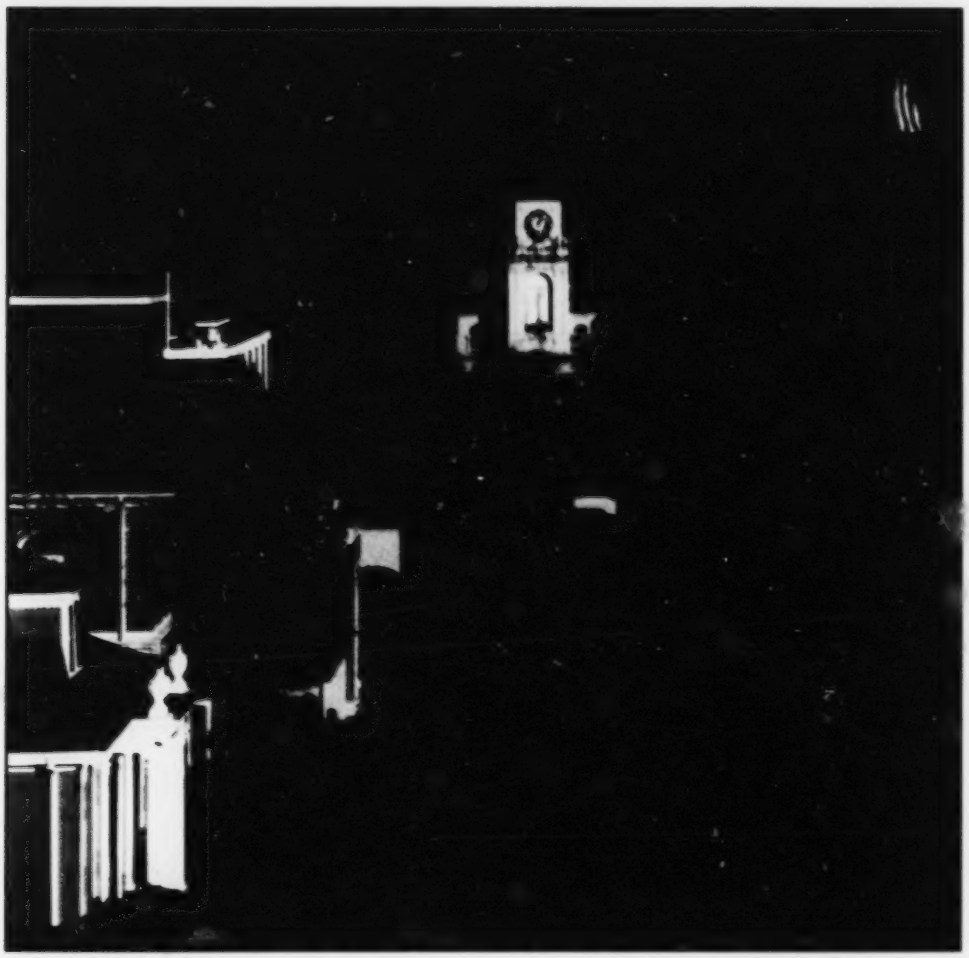
One of the most noteworthy examples of CBVC's success is the formation and launch of one of Colorado's newest and fastest growing biotechnology companies, Supragen, Inc. The company is formed around world-leading immunological research performed by Drs. Marrack, Kappler and Kotsin at National Jewish. It has grown from zero to more than twenty employees this year and currently occupies more than 8,000 square feet of lab space at the CBVC.

The company is exploiting a novel area of science known as super-antigens, which hold promise for such diseases as rheumatoid arthritis and rheumatic fever. Warburg Pincus, the world's largest venture capital firm, funded and organized the company. The CBVC received the 1993 Technology Transfer Award for "Technology Transfer Intermediary" from the Colorado Technology Transfer Society for its role in the development of Supragen.

Model Memorandum of Understanding with the National Institutes of Health

Another CBVC success is bringing CBVC national recognition. In 1993, after nearly two years of work, the CBVC signed, and is implementing, a national model agreement with the NIH aimed at improving access for Colorado's bio/medical companies to NIH research activities.. The Memorandum calls for three types of technology transfer: 1) the formation of new companies based on NIH research; 2) the matching of Colorado company product development efforts with NIH research interests; and 3) the general education of Colorado companies on the means of working with NIH.

The agreement has put the CBVC in a national leadership position and may lead to significant federal support for the Center as well as enhanced access to the results of billions of dollars of federal research for Colorado companies.



The Colorado Bio/Medical Venture Center, located at the AMC Cancer Research Center, provides an ideal environment for its client companies.

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Colorado Bioprocessing Center

The Colorado Bioprocessing Center is a state-of-the-art units operations laboratory for biotechnology commercial manufacturing processes. It is a unique facility in which the products of laboratory-based advances in modern genetic engineering and cell culture can be rapidly translated into a commercial process.

The Center is housed in a 3,000 square-foot facility on the Colorado State University campus. The construction, operation and development of the Center is a major success story in its own right. The Center is an example of the joint cooperation of public sector (government and academia) with private industry to create a resource not otherwise available in the western United States.

Technology transfer with companies — both to and from the Center — is the Center's dominant feature of activity. The Center has been used to perform process development and scale-up studies for a number of industrial companies within Colorado and throughout the U.S. The Center also provides advanced-level courses and industrial training programs to biotechnology companies, and trains graduate, undergraduate and high school students in areas of critical need to industry, thus providing a unique link of an educational institution to businesses. The high quality of facility and staff at the Center helps to attract good researchers and graduate students to biotechnology research, and to support the proposals for federal money from the National Science Foundation.

Center's Training Programs Benefits Local Workers and Companies.

Among the Center's most important contributions to Colorado's economy is its training programs. The Center has been used to train industrial personnel in basic fermentation and downstream processing techniques in courses ranging from one day to one week.

For example, Synergen, Inc. of Boulder had a problem obtaining trained process personnel for their manufacturing plant. The Center helped solve that problem by training 60 plant operators and supervisors in a hands-on training course that mimicked the key components of the actual process. The Center assisted many local people who previously lacked adequate skills in biotechnology to get trained or retrained, and at the same time helped to create a highly skilled workforce for Synergen.

Syntex Chemicals Turns to Bioprocessing Center for Process Improvements

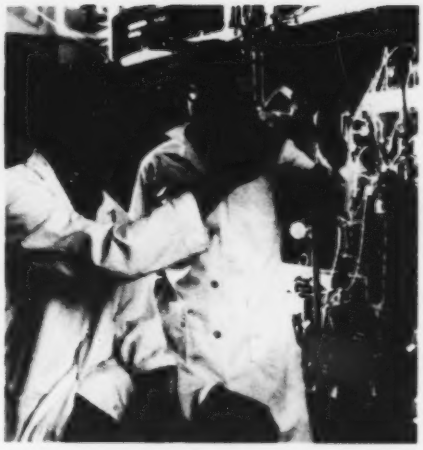
One of the Center's major achievements involves Syntex Chemicals of Boulder which manufactures and markets the nonsteroidal anti-inflammatory drug Naproxen. Because the patent on this major drug will soon expire, Syntex turned to the Bioprocessing Center for a more efficient biological route to a key step in the synthesis process in order to preserve the company's market dominance when it enters the public domain.

By working with the Center, Syntex was able to develop a process for the manufacture of a key enzyme for partial biological synthesis of the drug. This process is ready to be produced at a Syntex facility in Europe if the economics turn out to be favorable compared with an alternate chemical synthesis. Even though Syntex is a major corporation, the Center was able to provide important technology to advance this project in a timely and efficient manner.

Colorado Institute for Research in Biotechnology (CIRB)

Dr. Robert Davis, Co-Director
Dr. Vincent Murphy, Co-Director

The Colorado Institute for Research in Biotechnology (CIRB) promotes technology transfer to further develop the state's biotechnology industry. It accomplishes this in four ways: graduate student fellowships; matching funds for student internships at Colorado biotechnology companies; matching funds for key equipment in university biotechnology research labs; and faculty seed grants with a requirement for matching funds for industry. CIRB also publishes a newsletter, and sponsors the annual Colorado Biotechnology Symposium.



Dr. Robert Davis (left) and Dhinakar Kompala (right) at work at the University of Colorado's Department of Chemical Engineering.
Credit Ken; Abbott/University of Colorado

Seed Grant for RNA Work Leads to $1.3 Million NIH Grant for AIDS Study

A CIRB success story with enormous potential consequence involves unique research in the feasibility of using gene therapy to combat AIDS.

CIRB provided a $15,000 seed grant to Drs. Robert Schooley, Daniel Kuritzkes, and Thomas Campbell at the University of Colorado Health Sciences Center to work with Ribozyme Pharmaceuticals, Inc. (RPI) on evaluating catalytic RNA as molecular therapies for AIDS. Together with Professors Tom Cech and Bruce Sullenger at the University of Colorado, Boulder, the group received a $1.3 million grant from the National Institutes of Health in December, 1993 to continue this work.

The focus of the NIH grant will be on ribozymes, molecules of RNA that have a "cutting" function. This discovery of ribozymes by Cech in 1982 earned him the Nobel Prize in chemistry in 1989. While ribozymes' cutting function does not normally apply to human viruses, it is hoped that through the collaboration with the Health Sciences Center and CU-Boulder, RPI will ultimately be able to synthetically develop a ribozyme that will specifically identify HIV RNA, cutting it and rendering it useless without damaging normal, functioning cells in patients.

Seed Grant Leads to Improved Rotary Filtration Techniques

Another example of CIRB's many successes is a seed grant awarded to Professor Robert Davis of the Department of Chemical Engineering at the University of Colorado in Boulder for the study of "Rotary and Tangential Filtration for Protein Recovery from Cell Debris." This project received matching funds support from both a Colorado company and a New Jersey company. Through experiments and modeling, Professor Davis' laboratory group was able to demonstrate rotary filtration and tangential filtration techniques applicable to the companies' needs and with improved performance.

Seed Grant Leads to New RNA Technology and the Formation of NeXagen, Inc.

This CIRB success story features a seed grant awarded to Professor Larry Gold of the Department of Molecular, Cellular and Developmental Biology at the University of Colorado, Boulder, who founded NeXagen. The CIRB grant supported some of Professor Gold's initial work on the use of Systematic Evolution of Ligands by Exponential Enrichment (SELEX) to identify oligonucleotide ligands which are able to bind with extremely high affinity and specificity to molecular targets.

To explore the commercial potential of the SELEX technology, Gold founded NeXagen in 1991. To date, this technology has been used to discover RNA ligands to treat cardiovascular disease, inflammation, immunology, viruses, and cancer. The company's most advanced programs are directed at the identification and isolation of RNAs which bind and inhibit thrombin (a blood clotting factor) and proteins involved in the replication of the HIV virus associated with AIDS.

Creation of the Colorado RNA Center, An Outgrowth of Successful Technology Transfer

The RNA-based research at the University of Colorado in Boulder leading to the formation of companies like NeXagen has also led to the formation in 1992 of the Colorado RNA Center (CRC). Like the CIRB, the CRC is funded by the Colorado Advanced Technology Institute. CRC is supporting RNA research at CU-Boulder and other Colorado academic institutions on projects such as determining three-dimensional structures of RNA, developing RNA-based vaccines for poliovirus and other diseases, producing better plants using RNA, and devising more efficient technologies for making large quantities of purified RNA.

COLORADO ADVANCED SOFTWARE INSTITUTE (CASI)

Donald J. McCubbrey, Director

The Colorado Advanced Software Institute (CASI) provides matching funds for companies that want to collaborate with research universities on advanced software projects. It also provides seed grants to university researchers. Projects include software engineering, neural networks, expert systems, data base systems, and human-computer interface.

The Colorado State University Engines and Energy Conversion Laboratory located in the old Fort Collins Municiple Power Plant.

Engines and Energy Conversion Laboratory Collaborates With Business to Produce Fast Turn-Around for Research Results

One of CASI's most noteworthy achievements is the Engines and Energy Conversion Laboratory (EECL) at the Colorado State University. EECL is an engine research facility where research is conducted on the development of advanced techniques for the design and control of internal combustion engines, alternative fuels, and issues related to stationary natural gas engines. It grew out of two CASI seed grants to two faculty members in the Mechanical Engineering Department, Drs. Wade Troxell and Bryan Willson.

Research collaboration with business is at the core of activity at EECL. A consortium of several companies has contributed support to the large engine research. The three collaborating companies for the two initial CASI awards — Woodward Governor, Public Service Company of Colorado, and Hydrogen Consultants — all continue their efforts with the laboratory investigators. In less than two years, the laboratory, which is housed in a building owned by the City of Fort Collins and valued at $2 million, has employed over 45 students in 21 projects. It has a research equipment inventory exceeding $3 million accumulated through cash and in-kind donations. During its first year, EECL conducted research projects that brought in $300,000 in research contracts to CSU, and are expected to exceed $1 million in its second fiscal year.

Development of New Neural Network System Generates $800,000 of Follow-On Contracts and Leads to New Business Formation

One example of a highly successful collaboration between CASI and private industry features the work of Dr. Jerald Jones, Director of the Center for Artificial Intelligence and faculty member at the Colorado School of Mines. In 1989, Dr. Jones developed a neural network system for signal analysis in collaboration with Texas Instruments. The neural network technology developed by Professor Jones has generated over $800,000 of follow-on contracts at the Colorado School of Mines. The contracts include $200,000 with the American Welding Institute, $97,000 with MTS Systems of Minneapolis for a welding model built into an intelligent robot used for the JT-90 jet engine, and another contract for over $500,000 with MTS Systems as subcontractor to DARPA to develop a new

advanced imbedded fiber-optic sensor for a new submarine hull structure for the U.S. Navy.

In May 1993, again as a result of the 1989 neural network signal detection work Jones developed in collaboration with Texas Instruments, a new business was formed: Native American Technologies Company in Golden. Professor Jones is its Chief Scientist. The company already has $8 3,000 in contracts with Ford, Johnson Controls, Ball Container Company, and the International Nickel Company. It has also conducted unfunded research with Oakridge National Laboratories.

Academic and Business Collaboration Leads to Small Business Innovation Research Grant from NASA

Another noteworthy example of how CASI facilitates academic/industry collaborations which strengthen the Colorado economy is found in the case of Johnson Engineering. Johnson Engineering won a Phase 1 Small Business Innovation Research Grant (SBIR) for January through June, 1994 as a direct result of its collaboration on two projects with Professor Raymond McCall. McCall is a faculty member in the Environmental Design Program, New College of Architecture and Planning at the University of Colorado, Boulder. The SBIR is with Johnson's NASA client, the Flight Crew Support Division of Johnson Space Center. Johnson Engineering expects to proceed to a Phase 2 SBIR immediately at the conclusion of Phase 1. Moreover, Johnson Engineering's work with McCall indirectly enhanced its multimillion dollar proposal to NASA, which won funding during this past year.

Undergraduate Research Grant Results in an Intelligent Tutoring System for Novice Computer Users

Technology transfer success stories often feature the work of people in the advanced stages of their careers. This success story is different, yet it is no less impressive. While an undergraduate in Mathematics and Computer Science at Adams State College, Sheila Sylvester was awarded a CASI Undergraduate Research Grant. That grant resulted in the development of a novel computer tutoring program and the creation of a new business.

Ms. Sylvester's $2,000 two-semester grant from CASI enabled her to develop an intelligent tutoring system for novice computer users in the DOS environment. The system she developed provided guidance in the use of five DOS commands, offering feedback on the user's performance at appropriate times. Professor Marilyn Loser in the Computer Sciences Department supervised the study.

Leveraging her experience with the DOS project and an earlier experience teaching the rudiments of computers to customers in a computer outlet store, Ms. Sylvester opened her own business last summer in Alamosa, Colorado called "We Teach Computers." She credits the CASI Undergraduate Research Grant with providing the experience that made it possible for her to form her own business. Ms. Sylvester offers services to clients ranging from covering computer basics to increasing skills in various software programs (word processing, spread sheets, databases, and accounting). So far, her clients have included the Colorado Aggregate Company, San Luis Valley Rural Electric Cooperative, and the Rio Grande Savings and Loan in Monte Vista.

COLORADO OPEN SYSTEMS CONSORTIUM (COSC)

Jeff Richardson, Director, CATI Information Technology Programs

The Colorado Open Systems Consortium (COSC) is a dynamic group of professionals dedicated to promoting the adoption of open systems computing in Colorado's private and public sectors. Its mission is based on the belief that open systems computing leads to better economic performance, and is essential to corporate competitiveness. The healthy mix of member organizations and agencies has provided an excellent amalgam of perspectives by public and private sector representatives, including the academic community. In turn, members have been able to bring the examples of others' successes into their own operations.

The consortium offers educational and current events programs, and undertakes research projects of value to the membership. The outstanding growth in membership from all areas of the state is one of COSC's most impressive accomplishments. The organization has grown from zero to over 700 members in just three years time.

COSC is formally affiliated with the Interdisciplinary Telecommunications Program at the University of Colorado, Boulder.

Popularity of COSC Programs Demonstrates Need for Education and Information Sharing

Attendance at COSC-sponsored educational and training events is confirming the strong demand for advanced training in open systems computing, and is demonstrating COSC's success in fulfilling that need with its excellent events programs.

In 1993, COSC held four quarterly "CEO Breakfasts" featuring national speakers from industry (Motorola, Commercial Banks, and Covia Technologies) sharing their experiences on converting to open systems. COSC also offered four educational events: two introductory seminars, one client/server seminar, and one DCE seminar. These events have been attended by more than half of the membership, and several events have been oversubscribed. Almost 800 people attended OpenExpo, COSC's educational and technology demonstration forum, on March 24-25, 1993, which Governor Roy Romer proclaimed as "Open System Days."

COSC demonstrates the advantages of an organization dedicated to promoting the sharing of educational resources, that fosters cooperation among various institutions and organizations, and that enables participants to become knowledgeable about the very latest in advanced technological solutions.

COLORADO RURAL TELECOMMUNICATIONS PROJECT

Robert Horn, Director

The goal of the Colorado Telecommunications Project is to assist selected rural communities in identifying and implementing realistic steps to promote economic development through the use of telecommunications. Economic development is defined as increased income opportunities for residents as supported by the business, education, health care, and civic sectors of the communities. Rural communities or municipalities, regional consortia of local governments or rural development coalitions are eligible to participate in the program. Up to five communities or projects are selected annually through a competitive process.

Telluride InfoZone - A Pragmatic Response to a Regional Community's Needs

One of CATI's most innovative and successful examples of how a state-funded project can make use of existing and emerging technologies for economic and community development is the Telluride InfoZone. While Telluride best known for its ski peaks is not typical of small rural towns, it still suffers from infrastructure problems common to out-of-the-way places — schools that are poorly connected to the outside world, lack of access to state-of-the-art medical facilities, and rising costs. InfoZone is a wireless, community-wide network that distributes Internet and other data services to individuals with computers and modems in their homes and to public access computing sites around town. In 1993, the first phase of InfoZone was implemented, providing dedicated 56K phone circuit connection through Colorado SuperNet to the Internet; local access, gateway connection to commercial networks; and the beginnings of a community-wide education and information system.

Public access sites include the Wilkinson Public Library, the Telluride Arts Consortium, the Norwood Agricultural Extension Offices, and the Telluride Institute. Other terminals have been installed in the Telluride Medical Center, Telluride High School Library, and Telluride Museum. These terminals are being used to gather databases on historical, medical, and educational information that InfoZone designers will make available using sophisticated but user-friendly software.

Weekly InfoZone tutorials are well attended. Outreach and educational services are being provided to all of San Miguel County (Norwood, Placerville, Naturita), and to other regional communities (Ouray, Montrose, Ridgway). The InfoZone is also working actively with community networking groups in Durango, Boulder, Taos, and Santa Fe.

The Wall Street Journal, Business Week, WIRED Magazine, National Public Radio, and NBC News have brought to national attention Telluride's ability to attract "lone eagles" or "knowledge workers," professionals who, aided by modern communications technology, are able to work anywhere. Clearly, Telluride InfoZone is laying the foundation to take advantage of this demographic movement.

In addition to CATI support, initial support has come from the Colorado Trust and the National Civic League's Healthy Communities Initiative; IBM; US Robotics; US West; SuperMac; the Whole Earth 'Lectronic Link; the town of Telluride; San Miguel County; and Apple Computers through a Library of Tomorrow Award.

OPTOELECTRONIC COMPUTING SYSTEMS CENTER (OCSC)

Dr. Kristina Johnson, Director
John Neff, Managing Director
Dr. Brian Hooker, Associate Director for Technology Transfer

The mission of the Optoelectronic Computing Systems Center (OCSC), a National Science Foundation Engineering Research Center, is to provide a cross-disciplinary program to educate students in optoelectronic computing systems, thus creating new industries and a new workforce for the 21st century. The underpinning of the Center is a strong curriculum in optoelectronic materials, devices, packaging, computer architectures, neural networks and information processing in seven departments (computer science, electrical and computer engineering, mechanical engineering, chemistry, physics, mathematics and electrical engineering) at the University of Colorado and Colorado State University.

CATI and OCSC jointly developed the Colorado Business Program (CBP) which has enabled five Colorado small businesses to be Associate members of OCSC for the past two years, and to be active partners with OCSC researchers in optoelectronic research. By reaching out to Colorado small businesses, and by forging and funding partnerships between OCSC and those businesses, CATI has enabled the links to research and expert interactions that are essential for these small high-technology photonics businesses to prosper.

The original five businesses to participate in the Colorado Business Program are: Alpine Research, Boulder Non-Linear Systems, Displaytek, Hyperfine, and Photonics Research, Inc.

Photonics Research Inc. and OCSC Join Forces to Become World Leaders in Free Space Optical Interconnects

In only two years, Photonics Research Inc. (PRI) has emerged as one of the Colorado Business Program's most impressive success stories. As a participant in the CBP, PRI built upon its relationship with OCSC to enhance its large research and development program in vertical-cavity surface-emitting laser (VCSEL) arrays that is being funded by several different organizations in the U.S. Department of Defense.

PRI was founded in 1991 by Drs. Greg Olbright and Jack Jewell as a spinout of technology development at AT&T Bell labs and Sandia National Laboratory. PRI pioneered, developed and has begun to market Lase-Array™ based optoelectronic integrated circuits. Lase-Arrays technology has enabled the previously unattainable goal of fabricating large and uniform two-dimensional arrays of lasers with techniques and economies of scale similar to those enjoyed by integrated circuits.

Lase-Arrays are widely expected to play a key role in achieving the fiber-optic communication capacity and speed goals of the Information Superhighway. Several other application areas for Lase-Arrays include ultra-high speed data transfer from optical disks, multichannel fiber-based computer and free-space optical communication. It is widely expected that optical communications will not only dominate the Superhighway through the use of multichannel fiber links, but also will allow communication for computers, processors and very large-scale integrated circuits.

The Colorado Business Program enables small business to be active partners with OCSC researchers.
Credit: Ken Abbott/University of Colorado.

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SUPERNET — THE COLORADO COMPUTER NETWORK

Guy Cook, Chief Executive Officer

SuperNet manages the Colorado portion of the Internet, providing affordable Internet access to schools, businesses, and individuals across the state. It is an outstanding example of a CATI-sponsored technology transfer success story: SuperNet utilizes technological advances to tap into emerging markets, providing essential services which improve Colorado's schools, economy, and quality of life. In addition, SuperNet is CATI's first program to "graduate" into financial self-sufficiency after CATI provided several years of financial assistance required for SuperNet to establish, enhance and refine its basic infrastructure.

Colorado is out in front with this program, being the first to involve virtually all levels of education, one of the first to provide services for the private sector as well as the public sector, the first to offer reasonably priced state-wide dial-in access on a local call basis, the first to support local call access to state public libraries, and the first western state to experiment with Internet-based community computing.

SuperNet has had a number of noteworthy achievements:

- The SuperNet dial-in service has expanded its geographic presence to cover Alamosa, Boulder/Denver, Colorado Springs, Durango, Fort Collins, Glenwood Springs, Grand Junction, Greeley, Gunnison, Pueblo, Telluride, Summit County and Steamboat Springs. This has allowed small businesses, nonprofit agencies and individuals to receive SuperNet services without substantial capital investment. It provides a scalable method for businesses to move into full service dedicated connections as the need develops. The dial-in service enables local call access to the Internet for the majority of Colorado's citizens, and strengthens Colorado's position as a leader in state networking.

- The SuperNet Database Incubator Project is assisting nonprofit, educational organizations and rural communities in turning existing databases into widely available electronic formats. In association with this project, SuperNet has developed an extensive menuing system and related technical expertise which enables individuals access to Colorado databases on the global Internet with the latest search tools.

- SuperNet is providing dedicated high-speed Internet access to several school districts including Boulder Valley School District and Poudre R-1 School District. SuperNet is also providing dedicated access directly to seven Colorado high schools. Currently, approximately one hundred fifty Colorado educators access SuperNet through dial-in service.

Currently, SuperNet has 100 dedicated connections, and provides services to 5,000 dial-in subscribers. It is growing at 11%, a phenomenal rate of growth. 65% of SuperNet accounts are private sector accounts, therefore SuperNet is establishing a for-profit subsidiary. The original not-for-profit corporation will remain and continue its public good activities such as promoting Internet access to schools.

BOULDER TECHNOLOGY INCUBATOR (BTI)

Jerry Donahue, Executive Director

The Boulder Technology Incubator (BTI) is a not-for-profit public/private corporation created to assist in the development of technology-based business. BTI provides a professional community environment for entrepreneurs which fosters innovation, facilitates technology transfer, development and independence while also preparing the business for anticipated independence and growth. It has contemporary facilities for lease in both Boulder and Longmont.

BTI engenders economic development and stability through management assistance to the businesses it serves, resulting in an increase and dispersion of quality primary jobs in the community and state. Current graduates include Avalon Engineering, Bolder Battery, Coral Systems, and Gateway Technologies.

Avalon Engineering Improves Product and Achieves Profitable Operation With BTI Assistance

One of the BTI's most noteworthy graduates is Avalon Engineering, Inc. which manufactures and sells the SafetyCycle Industrial Vision System. Over the past few years, Avalon has become the industry leader in mold monitoring systems for the United States plastics industry. Contributors to the technology development include CIBA-GEIGY, Mitsubushi, Courtualas, Shawmut Mills, Sunbeam, Tempo-Shain, Programmed Composin-3, Crandoe, Gaymar, Darlington, Monsanto, Cytec, Kansas State University, the University of Leipzig, and dozens of others. Numerous strategic alliances were established throughout the process of bringing the technology to market including research, development, design, production, manufacturing, marketing, sales and distribution.

SafetyCycle sales in 1992 were $800,000. Avalon achieved profitable operation in 1993 and sales were projected to be $2 million by year end. Avalon continues to improve its products by incorporating the most advanced technologies. A new product line which will provide plant-wide monitoring, employing network capabilities, is the thrust of a major product development effort in 1994. Avalon also plans to expand into specific parts' inspection markets with this product.

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COLORADO INSTITUTE FOR TECHNOLOGY TRANSFER AND IMPLEMENTATION (CITTI)

Dr. Larry Anderson, Director

The Colorado Institute for Technology Transfer and Implementation (CITTI) focuses its work in four areas: coordinating University of Colorado, Colorado Springs' technology transfer activities; encouraging scholarly work in technology transfer; offering one-one-one help to local businesses by making the university's technology available to them; and sponsoring networking and training activities in El Paso County. CITTI serves as a liaison to federal laboratories such as Sandia National Laboratories. It has created the Colorado Springs Venture Capital Network, which is designed to bring together local start-ups and potential sources of capital.

MCI and UCCS Faculty Team to Solve Network Restoration Problems

One of CITTI's most notable successes in making UCCS faculty and students available to local companies to solve real-world problems involves MCI Communications Corp. CITTI coordinated an $83,000 grant from MCI to UCCS to study telecommunications network restoration. A professor and three students researched how other telecommunication systems restore service after an outage and whether there are new ways to solve the problem. Network restoration is a key issue in the high-stakes, highly competitive telecommunications industry. Outages, like the one suffered by AT & T in 1991, can cause massive service disruptions. MCI plans to build a prototype restoration model based on the research and then to see if it would complement the company's existing restoration system.

CITTI Links Entrepreneurs With Federal Lab To Launch New Semiconductor Memory Technology

An excellent example of CITTI's achievements in facilitating technology transfer from the laboratory to the marketplace is NVX, Inc. NVX is a semiconductor start-up company in Colorado Springs founded by two engineers, Loren Lancaster and Ryan Hirose, who left an existing semiconductor company to pursue their dream of a better nonvolatile semiconductor memory technology. In the process, they came to CITTI for help. They were faced with the classical catch-22 of the high technology entrepreneur: they had no money to do the prototyping that would prove that their idea worked, and without proof-of-principle, they found that no one would give them money. CITTI's role, in part, was to try to break this vicious circle by going after federal help.

The semiconductor memory technology invented by NVX was, by good fortune, of "dual use." That is, in addition to civilian applications in products such as laptop computers and portable telecommunications gear, it also had potential defense applications because of its unique characteristics. Armed with this information, CITTI was able to convince the management at Sandia National Laboratories in Albuquerque, New Mexico, one of the country's leading defense and energy research establishments, to consider prototyping the technology at no cost to NVX. Conversely, given Sandia's interest in its technology, NVX was able to interest private investors in the company with the help of CITTI's Robert Keeley, UCCS El Pomar Professor of Finance.

The results thus far are very encouraging. Sandia has successfully prototyped the NVX technology and the company has successfully completed a private financial placement. The NVX principals have moved into expanded quarters in Colorado Springs and have begun to actively market their technology.

COLORADO TECHNOLOGY ACTION CONSORTIUM (COTAC)

Sue Morgan, CATI Deputy Director

The Colorado Technology Action Consortium (COTAC) is a non-hierarchical network initiated in late 1991. It is made up of two hundred and fifty members representing federal laboratories, universities, private sector service providers, small business incubators, economic development entities, and state and federal government agencies. COTAC's goal is to develop cooperative, coordinated activities within Colorado conducive to dynamic techonomic growth. CATI acts as COTAC's organizational and administrative network node.

The COTAC process begins when one or more COTAC members identify an opportunity in technology transfer, or a problem, often some kind of barrier to technology transfer. Self-selecting teams meet to talk about solutions, develop plans, and identify resources. Often, these resources are a pooling of existing resources brought by the team members. Every plan for action begins as a boot-strapping, self-funded activity. Each viable idea and plan then takes on a life of its own, and is guided by the vision, resources, and energy of the team members.

COTAC's value is three-fold. First, COTAC provides a legitimizing mechanism under which many organizations can work together in a turf-free, non-competitive environment. Second, COTAC serves an invaluable communication function in the creation of an emerging coalition of people who use technology transfer as part of getting their jobs done. Third, COTAC teams address needs within Colorado that no single participating organization has the resources to provide. COTAC makes Colorado's technology transfer pie bigger through cooperation, coordination, outside funding, and infrastructure development.

The following are a few examples of various COTAC committees' successes:

- The Proposals Committee developed the proposal for a U.S. Department of Commerce Economic Development Administration planning grant which culminated in *The Colorado Technology Transfer Plan for Economic Development.*
- The Defense Conversion Committee coordinated twenty Colorado Technology Reinvestment Project proposals for the U.S. Advanced Research Projects Agency and generated two proposals of its own.
- COTAC printed three editions of the Colorado Technology Transfer Directory which profiles companies and individuals involved in the technology transfer process, the kinds of work they do, and the services they can provide.
- A subcommittee of the Federal-State-Local Committee developed a plan to provide training for business advisors to help them identify when technology could benefit their client businesses, to select appropriate technology resources, and to understand tools for technology transfer acquisition. The committee secured funding for this plan from non-state revenue sources.

COTAC demonstrates the advantages of creating mechanisms that promote the sharing of information and resources, that foster cooperation among various institutions and organizations, and that enable participants to maximize existing resources.

MID-AMERICA MANUFACTURING TECHNOLOGY CENTER (MAMTC)

Wade O. Troxell, Executive Director

The Mid-America Manufacturing Technology Center (MAMTC) at Colorado State University strives to meet the ever-changing and diverse needs of the manufacturing sector. Field Engineers work with manufacturers in a number of areas such as quality improvement, product design, protect testing, cost measurement, equipment and software selection, inventory control, materials handling, and computer aided design.

MAMTC's technology resources consist of university, community colleges, federal laboratories, and private sector consultants. Believing that industry-driven projects provide a strategic framework for sponsored research based on the needs of society and not simply curiosity-driven research, MAMTC provides manufacturers with fresh insights and dynamic academic teams.

University Partnership with Fischer Imaging Provides Solutions to Real-World Problems

One of MAMTC's success stories came as a result of Fischer Imaging's need to update and improve their information systems. A team of three graduate students and three faculty members from Colorado State University reviewed Fischer's Management Information System. They then identified current and potential user applications, and presented unbiased, objective recommendations for improvement. The disciplines represented included computer information systems and industrial services.

MAMTC acted as the facilitator and administrator of the CSU-Fischer partnership. By organizing university students and faculty, MAMTC was able to offer superior technical expertise to meet the exact needs of Fischer. The university-business partnership exemplifies a new call for service colleges that seek solutions to real-world problems, instead of focusing on isolated "ivory tower" research. CSU and MAMTC approached the Fischer project as an opportunity to test, as well as define future research based on the realities of business in a competitive climate.

Tenneco Gas Transportation Looks to Engines and Energy Conversion Laboratory For State-of-the-Art Emissions Testing

Another technology transfer facilitated by MAMTC resulted in sponsored research based on society's needs to improve air quality. MAMTC successfully facilitated a technology transfer partnership between the Engines and Energy Conversion Laboratory, one of the twenty-eight Manufacturing Excellence Centers at Colorado State University, and Tenneco Gas, one of the nation's largest transporters of natural gas. Tenneco is under a federal mandate to develop new technologies that will enable them to meet the federal Clean Air Act. The Clean Air Act guidelines require the emissions from natural gas compressor engines to be reduced by up to 80% by 1995. Like many firms, Tenneco does not own equipment reserved solely for testing and developing new products. In the past, Tenneco has canvassed their existing installations searching for an engine that could be used to test off-line newly developed emissions control equipment.

MAMTC Field Engineer Karen McIntosh identified the large-bore Engines and Energy Conversion Laboratory as a resource that would provide Tenneco Gas with an operational state-of-the art Beta testing site as well as skilled faculty and student personnel to run their tests within critical schedules. Tenneco has been pleased with the responsiveness of the EECL, and continues to research, develop, and test the new technologies at Colorado State University.

The Woodward Governors Smart 3000 Engine Control and monitoring station at the Engines and Energy Conversion laboratory.

COLORADO ADVANCED MATERIALS INSTITUTE (CAMI)

Dr. Frederick J. Fraikor, Director

The Colorado Advanced Materials Institute (CAMI) was formed to provide a state-wide focus and catalyst to stimulate cooperative efforts between Colorado research universities and the materials business community.

Through its Seed Grant Program, CAMI has successfully stimulated advanced technology materials research of direct interest and value to Colorado industries while attracting matching funds from federal and private sources. A total of $2.61 million in state funding from FY84 to FY94 generated matching funds of $4.1 million for materials research and development in the State.

The objective of these seed grants is to stimulate university/industry collaborative efforts in advanced materials technology to enhance the competitiveness of Colorado industry. The seed funding (up to $10K) creates a path for technology transfer between the collaborating industries and universities. This catalytic process has contributed to new knowledge and opportunities for both students and faculty in Colorado universities as well as participating companies.

Research Funded by CAMI Seed Grants Results in $5 Million Department of Defense Award to Martin Marietta

A truly impressive CAMI success is the cooperation between engineers at Martin Marietta Corporation and two researchers at the University of Denver which resulted in new, cutting-edge applications for Shape Memory Alloys. Shape Memory Alloys, commonly referred to as "smart metals," have the ability to retain their "memory" of a prior shape or configuration during its initial processing and heat treatment. Subsequent applications of heat immediately induces a dramatic phase change and the metal reverts back to this initial shape. Early applications of these smart alloys include automatic overheat shut-off values and control devices.

Martin Marietta engineers proposed to the Defense Advanced Research Projects Agency (DARPA) that this class of materials could be used for control surface actuators (e.g. wings, airfoils) and sensors, thereby potentially eliminating cumbersome and weighty hydraulics and mechanical linkage systems in aircraft. The key, however, to a cost-effective utilization of these advanced materials was the ability of Martin to devise and design a new, efficient and reliable production process. The Martin engineers called on Dr. Steve Carpenter and Dr. Paul Predecki for research assistance to explore innovative in-situ, real-time measurement to aid in the processing and quality control of these unique metal alloys. With the assistance of CAMI seed grants, Professor Carpenter studies acoustic emission phenomena in these materials while Professor Predecki and his graduate students researched the use of X-ray diffraction techniques. Both investigators and international authorities in their respective fields and Martin cited their expertise and the support of CAMI in their proposal to the Department of Defense.

The subsequent award of approximately $5 million to Martin Marietta at Denver has helped to mitigate the impact of other aerospace and defense cutbacks at the Denver facility, and has opened an avenue for possible military and commercial applications of these advanced materials.

CAMI Superconducting Team Produces Technological Innovations

CAMI marked the fifth anniversary of the discovery of high-temperature superconductors by awarding $28,358 to a Colorado university/industry research team. The recipients of this seed grant were Professors Allen Hermann, CU-Boulder, and John Trefny and Baki Yarar of the Colorado School of Mines. Until very recently, Dr. Hermann held the world record for discovery of the highest temperature superconducting material. Two Colorado companies, Superconducting Core Technologies, Inc. (SCT) and Symetrix, were also involved in the project. SCT, a small business, provided support for two post-doctoral research associates and two graduate students.

The team cooperated on a project to develop hybrid electronic devices containing high-temperature superconducting and tunable ferroelectric thin films. This work was highly successful. The Colorado School of Mines group developed techniques to synthesize superconducting materials of various compositions and to produce thin films of tunable ferroelectric materials by rf-sputtering. At CU-Boulder, these materials were fabricated into successful prototype devices containing the high-temperature superconducting films. Several patents are currently being pursued by the CU-Boulder group in collaboration with Superconducting Core Technologies, Inc.

These world-class Colorado developments in advanced superconducting materials were subsequently incorporated into a $11.7 million defense conversion proposal to ARPA, involving the Colorado School of Mines, CU-Boulder and SCT as well as NIST, NREL and Martin Marietta Corporation. This consortium, called the Center for Advanced Superconducting Telecommunications Technology (CASTT), is another example of Colorado expertise at the frontier of the vast telecommunications technology area.

CENTER FOR SEPARATIONS USING THIN FILMS (CSTF)

Dr. William B. Krantz, Co-Director
Dr. Richard D. Noble, Co-Director

Separation processes constitute a large segment of materials processing in the chemical, petrochemical, and gas separation industries. The cost of separation can be 80% of the total processing costs, especially for commodity chemicals. Thin films, such as ceramics and polymers, offer new possibilities for efficient separations, with a resulting impact on the user-industry's capital and operating costs and energy consumption.

CSTF was established to advance the technology of thin film separations. CSTF involves faculty and students from the Departments of Chemical Engineering, Mechanical Engineering, Chemistry, and Physics at the University of Colorado, and the Department of Chemistry at Colorado State University.

The main objectives of the Center are to: conduct basic research and related developmental activities using thin film technology in separation processes; to provide rapid technology transfer between the Center research projects and industrial participants; and to promote graduate studies of thin film technology. The Center seeks to achieve its objectives through an industrially-relevant program of leveraged research.

CSTF provides convenient access to University researchers, students and facilities. In addition, the Center provides a forum for dialog between sponsor companies and government research laboratories with common interests. Sponsor companies receive the results of several research projects for a

Center for Separations Using Thin Films co-director Dr. Williams B. Krantz examines a sample using the center's high resolution electron microscope. This NSF industry/university cooperative research center performs innovative research on separation technologies that save money and energy for industry.

cost lower than a single project with normal overhead. The benefits to the university include the opportunity to engage in meaningful interdisciplinary cooperative research on important problems of interest to industry. CSTF sponsors in 1994 included Chevron Corporation, Dow Chemical Company, DSM Research, DuPont, Gas Research Institute, Los Alamos National Laboratory, 3M Corporation, UNOCAL, and the U.S. Environmental Protection Agency.

Chevron Collaboration Results in New Compounds, Patent Applications and Federal Funds

Chevron's collaboration with faculty at the Center provides a superior example of how university researchers and businesses can benefit when they are brought together by a state-supported technology transfer infrastructure.

Chevron Research and Technology joined the Center as a Charter member in 1990. Their reasons were three-fold: obtain relevant research, get leveraged funding and gain access to the faculty and facilities of the Center. A project was initiated in 1991 on the use of moydenum-dimer compounds for reversible chemical complexation with olefins. The Center faculty who worked on this project were Richard Noble in Chemical Engineering and Mary Rakowski-DuBois in the Chemistry Department. Prof. Rakowski-DuBois synthesized and characterized various compounds, and Prof. Noble evaluated their separation potential. Chevron decided to fund an additional project with Prof. Rakowski-DuBois on this topic to gain additional advantage in the transfer of this technology. Two patent applications have been filed on these materials and the patents should be issued very shortly.

Chevron has also funded two additional projects based on their interactions with Center faculty and the potential of research to Chevron. One project involves the synthesis and characterization of zeolite membranes for hydrocarbon separations. CU researchers Richard Noble and John Falconer in the Chemical Engineering Department are the first research group in the world to successfully fabricate a zeolite membrane in a cylindrical tubular configuration. Chevron currently has several processes which use zeolite pellets, and they expect these membranes to provide large improvements in process energy efficiency and productivity.

A second project involves Richard Noble and Chris Bowman in the Chemical Engineering Department and Carl Koval in the Chemistry Department. Various membranes are being fabricated and tested which can provide very high selectivity for olfin separations. This project is being funded by the National Science Foundation with matching support from Chevron. The Chevron matching funds and letters of support were very important in NSF's decision to fund this project.